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Hedging Cotton Price Risk in Francophone African Countries

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Cotton futures can give the francophone Africa cotton-producing countries an additional instrument for risk management. Simulations show significant benefits in risk reduction.

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Summary findings

Cotton exports account for a significant share of total commodity exports in francophone African countries, suggesting that these countries have a large exposure to volatility in cotton prices.

An analysis of the cotton marketing systems in these countries revealed that most of the price risk is borne by the parastatals and ultimately by the government. This has led to problems in years of low cotton prices when the government maintained high producer prices. In recent years, these countries introduced some flexibility in their pricing policies to deal with that problem.

As a means of managing their cotton price risk, francophone African countries have been using forward sales. Between a quarter and a third of exported cotton has been sold forward before harvesting.

Forward sales have provided only limited coverage against price risk. The use of cotton futures and options could increase this risk coverage. Futures and options contracts can also give these countries flexibility in their sales strategies.

Countries planning to privatize their cotton marketing sectors should consider the use of futures and options because forward sales are likely to decline significantly in a privatized system.

The authors examined the feasibility of using New York cotton futures and options contracts as hedging instruments and found that there were benefits of reduced price volatility. Simulations for 1989, 1990, and 1991 show in every case that hedging was effective in reducing price risk from 30 percent to 60 percent. For every 1-percent reduction in risk, the reduction in income ranged from 0.66 percent to 1.12 percent.

This paper—a product of the International Trade Division, Internationational Economics Department — is part of a larger effort in the department to investigate the feasibility and benefits of using risk management instruments by primary commodity producers and exporters in developing countries. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Dawn Gustafson, room S7-044, extension 33714 (48 pages). December 1993.

HEDGING COTTON PRICE RISK IN FRANCOPHONE AFRICAN COUNTRIES

by

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INTRODUCTION [1]

Cotton is a very important crop for the Francophone African (FPA) countries. As a percentage of agricultural export revenues, cotton export revenues ranged from 6% for Côte d'Ivoire and Cameroon to 68% for Burkina Faso in 1990 (see Table 1). As can be seen from this table, reliance on cotton exports has increased over time for the majority of FPA cotton producers.

The significant share of cotton in agricultural (and total) exports for many FPA countries, implies an exposure to the volatility in cotton prices. Moreover, by guaranteeing a fixed price to the farmers, FPA governments assume the risk from cotton price fluctuations.

Table 1: Francophone Africa: Cotton's Share of Agricultural Export Revenues in the Main Cotton Producing Countries

	1964-70	1971-80	1981-90
	------------ (%) ------------		
Benin	13	27	59
Burkina Faso	12	36	68
Cameroon	8	4	6
Central African Republic	39	26	26
Chad	69	45	33
Côte d'Ivoire	1	3	6
Mali	13	37	25
Senegal	0	5	9
Togo	5	5	35

Source: Calculated from data on FAO trade tapes, 1991.

[1]We would like to thank Jim Steel of REFCO for providing us with data and information. We would also like to thank Ronald Duncan, Vikram Nehru, and Luc De Wulf for valuable comments.

At present the only instrument used for risk management in FPA countries is forward contracts. By the planting season, when governments fix the producer price for the year, they usually have sold about a fourth of the expected crop forward. This still leaves a significant part of price risk unhedged. The use of cotton futures/options contracts can supplement forward sales in order to achieve a more desirable level of hedging. In addition, futures contract can add to the flexibility of the selling decisions.

The recent liberalization efforts in FPA countries' cotton marketing systems are likely to increase the need for risk management. This is because with market liberalization, forward sales are likely to diminish as counterparty risk may become larger when dealing with new private exporters. The use of futures/options can, to an extent, substitute for forward sales and provide price risk reduction.

This paper addresses the issues, focusing on the allocation of price risk within the existing cotton marketing system in FPA countries and the implications following market liberalization. The paper also quantifies the cotton price risk and investigates the appropriateness of using N.Y. cotton futures contracts to hedge FPA cotton price risk. In particular, simulations using the N.Y. cotton futures contract show how cotton price volatility is reduced by using that contract. In addition the paper provides some indication of the trade-off between risk and return when hedging. This analysis includes sensitivity analyses with regard to the assumed risk aversion and the "bias" between the current and the expected futures price. We end with some discussion of how the FPA countries can use hedging techniques.

The paper is structured as follows: Section I of the paper describes the marketing characteristics for cotton in FPA countries, focusing on the issue of the allocation of cotton price risk within the cotton marketing chain. Section II quantifies the cotton price risk and investigates the appropriateness of using N.Y. cotton futures contracts to hedge FPA cotton price risk A simulation using the N.Y. cotton futures contract is carried out in this section to show that cotton price volatility is reduced by using N.Y. cotton futures contracts. Some indication of the trade-off between risk and return is also given. Section III summarizes and concludes.

I. COTTON MARKETING IN FRANCOPHONE AFRICA

From the mid-1960s through the 1970s, cotton growing in Francophone Africa benefitted from the development of improved varieties and increased use of fertilizers and pesticides. Although the cotton growing area increased only slowly (0.8% p.a.) over this period, production increased at an annual rate of 6.6% due to the rapidly increasing yields. These successes led to an increase in the rate of expansion of the cotton growing area and further increases in yields. During the 1980-90 period, therefore, cotton production in the region increased at an annual rate of 9.7% p.a.. With domestic consumption increasing only slowly, most of the increased production was exported.

The increasing dependence on cotton export revenues has raised the importance of the risks from cotton price fluctuations, especially since the impact of the price fluctuations is sometimes intensified by unfavorable changes in the exchange rate between the French franc and the US dollar. The need for good management of these price risks was dramatically demonstrated during the two most recent price cycles--in 1985/86 and 1991/93.

The early development of cotton production in the Francophone region was supported by the Institut de Recherché des Textiles Exotiques (IRCT) which established agricultural research stations in the region to provide technological support to the cotton industry and the Campagnie Francaise des Textiles (CFDT) which supplied inputs, credit, extension information, marketing services, the operation of ginneries and oilseed mills, and the transport of baled fiber to ports and its export. Marketing services included the purchase of seedcotton from farmers at prices announced by the government with no direct relationship to prices obtainable in export markets. Over time, as local personnel gained experience, the responsibilities for these services were assumed by parastatal organizations owned jointly by the country and the French government, such as Societe des Fibres Textiles (SOFITEX) in Burkina Faso and Compagnie Malienne pour le Dévelopment des Textiles (CMDT) in Mali.

A common element of the marketing system was a price stabilization mechanism which, in principle, accumulated funds during seasons of relatively high prices to cover the deficits during years when low prices prevailed. In practice, however, the available funds were often insufficient to support prices during a prolonged period of low prices. In this case, the deficit had to be assumed by the national budget. In other words, the price risk was transferred to government revenues. Following massive disasters to the cotton marketing systems during the period of low cotton prices in the mid-1980s, substantial reforms were implemented.

The reforms taken were country-specific but there were common elements. The changes were mainly focused on the producer pricing arrangement, the phased reduction and elimination of input subsidies, the institutional marketing system, and the taxation of cotton. Producer prices in some countries have been made more flexible by making the price received upon delivery of the seedcotton only a portion of the total expected price. The total return to farmers is dependent on profits made by the marketing organization after the final sale of the entire crop. In some cases, the function of the marketing agency has been changed so that it operates under a negotiated fixed-price contract for its services--in effect it operates with assumed risks and incentives to encourage operating efficiencies similar to a private marketing system. Moreover, accounting systems have been changed to accommodate a separation of costs incurred from cotton activities from those incurred from other activities performed on behalf of the government. In effect, these changes have shifted some of the cotton price risk from the government to farmers and the marketing organization.

Currently, the Francophone countries use forward sales to hedge the price risk. In recent years the marketing agencies have sold forward from one quarter to one third of the expected crop by the time the crop has been planted (see Tables 2 and 3). This is limited coverage of the price risk; a limitation which may be due to the credit risk involved in forward contracts, as reflected in the probability that the counterparty will not fulfill the contract and the difficulty of finding buyers at the appropriate time. Futures market overcome this credit risk by "marking to market" on a daily basis. In principle, futures markets are always available--at least for the period in which there is sufficient liquidity.[2]

Table 2: Francophone Africa: Cotton Planting and Harvesting Patterns

Country	Planting Dates	Harvesting Dates
Benin	June-July	Oct-Dec
Burkina Faso	June-July	Nov-Dec
Cameroon	mid-July	Nov-Dec
Central Africa Republic	Late June-early July	Nov-Jan
Chad	June	Nov-Dec
Côte d'Ivoire	June-Aug	Oct-Jan
Mali	June-July	Oct-Dec
Senegal		
Togo	June-July	Nov-Dec

Source: International Cotton Advisory Committee.

[2]The total annual cotton production of FPA countries is approximately 550,000 tons. In the New York cotton futures market 260,000 tons are traded daily. The majority of the trades is concentrated in the four nearby contracts, covering about 7-8 months ahead. Options contracts are less liquid. There is daily trading of about 100,000 tons of cotton in options with liquidity concentrated in the two nearby contracts, covering 4-5 months ahead. The size of the N.Y. cotton futures contract is 50,000 lb (roughly 23 tons).

Table 3: Francophone Africa: Seasonal Cotton Export Commitment 1989/90 to 1992/93

	Marketing Year							
	1989/90		1990/91		1991/92		1992/93	
Volume/Share	Tons	Share	Tons	Share	Tons	Share	Tons	Share
		(%)		(%)		(%)		(%)
Sales date								
Mid-July			163	34	128	25	77	14
Mid-Aug/Sept			200	42	205	40		
Mid-Nov	272	60	233	48	260	50	182	34
Mid-Jan	296	65	309	64	327	63	305	56
Mid-March	413	91	388	81	469	90	329	61
Mid-May	430	95	450	94	482	93	461	85
Crop-Year Exports	455		481		519		543 est	

Source: International Cotton Advisory Committee.

International markets for commodity futures and options offer an efficient way to provide short-term (intra-year) price stability to farmers and it is often in the interest of exporters, and other intermediaries and local banks to provide such services to farmers (for example, to reduce the risk of loan default).[3] However, exporters and local banks will be constrained in offering such risk management services to farmers if price signals are not transmitted efficiently and price formation is not transparent. Such problems could be due to noncompetitive transportation and storage systems, lack of harmonized grading standards, and government interference along the marketing chain (see Larson, 1993; and Varangis, Thigpen, and Akiyama, 1993). In addition, local exporters, traders and banks will be constrained in using commodity futures exchanges by their cash flow ability to obtain margins for futures contracts. Creditworthiness issues can also provide a constraint, as brokerage firms may not be willing to take the country risk.[4]

Under the present cotton marketing systems in FPA countries the majority of the price risk falls on the parastatal marketing organization and ultimately on the government. In a liberalized marketing system in the absence of risk management practices the majority of price risk is likely to be borne by the farmer. In the

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[3]Farmers are not expected to use futures and options directly. Large exporters and intermediaries are more likely to use them enabling them to provide short-term price stability to the farmers.

[4]The creditworthiness of the particular exporter, trader and bank is less of a concern as margin calls deal with this problem.

case of privatized cotton export marketing, the use of forward sales is likely to diminish because of counterparty risk. Private exporters, particularly newly established ones, are perceived by foreign traders as being a greater risk than parastatals (for example, the case of cocoa in Nigeria). In that case, futures contracts can substitute for forward export sales. In addition, domestic cash and forward markets can provide efficient mechanisms for transferring risk from farmers to intermediaries, banks and private exporters. However, because the latter handle large volumes, they can pool risks of a large number of farmers and hedge it in the international markets by using cotton futures/options markets. Thus, domestic cash and forward markets provide mechanisms for internal risk sharing with the risk not leaving the country (risk is internalized), while futures/options markets externalize the price risk by placing it in the international market where agents are more capable and more willing to absorb it. The combination of domestic cash/forward and international futures/options markets is likely to provide the most transparent and efficient (lowest cost) way of risk sharing and short-run price stabilization.[5]

The Costa Rican coffee marketing system is a good example of such a system (see Claessens and Varangis, 1993). Farmers receive a first payment for their coffee from the miller/exporter at time of sale with subsequent quarterly payments and a final payment at the end of the year. Before millers/exporters began to use futures/options they advanced only a relatively small fraction of the expected price due to the uncertainty of the final price at the end of the year. However, with the adoption of financial risk management, the millers/exporters advance a significantly larger part of the expected price and hedge their exposure by buying put options (the premium for the purchase of these options is charged

[5]The establishment of cash/forward markets is not the only mechanism that can provide internal risk sharing in primary commodity markets. There are informal risk sharing arrangements, such as activity diversification. However, formal cash/forward markets provide a transparent price discovery system, wide dissemination of pricing information and a guarantee that contracts will be honored. The development of these functions is particularly important in a newly liberalized marketing system. With the withdrawal of government from the marketing system, commodity buyers and sellers are uncertain how prices will be determined, how they can find price information about similar qualities, and whether they will be paid for their sales or receive the commodities they paid for.

to the farmer).[6] In this way, the Costa Rican coffee farmer has protection against coffee price falls.

Another example is Mexico, where the recent liberalization of the grains and oilseeds marketing system calls for the creation of regional spot and forward markets. Under the new system farmers are to use the domestic forward markets if they want to "lock-in" a price for some future period and larger trading firms will be able to pool, via the forward markets, the price risk from several farmers and hedge it in the US commodity exchanges. Processors can use forward markets also to hedge their input costs. Sellers of forward contracts (mainly farmers) collaterlize their transations with their warehouse receipts while the buyers of forward contracts have initial and variation margins.

The establishment of spot and forward markets requires that several preconditions need to be met.[7] Among the most important ones are: no government intervention in price setting; many buyers and sellers; equal access of market information; the existence of widely acceptable warehouse receipts; acceptable quality

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[6]Before options were widely used in the Costa Rican coffee marketing system, exporters/millers advanced 40-50% of the expected final price. Even with this low first payment, there were three years in the last 15 years that a number of Costa Rican exporters/millers went bankrupt because of large unexpected declines in coffee prices. With the use of options, exporters/millers now advance up to 80% of the expected final price.

[7]For an extensive discussion see Glaessner, et. al., 1991.

classification standards; property rights; and enforceability of contracts. At present, most of the necessary preconditions are hard to meet in most FPA countries. The governments in these countries should try to provide the appropriate legal and regulatory framework that would aid the development of forward markets. A role that the parastatals could play in the interim period is that of a buyer of last resort. Also complying with contracts could foster the credibility of the new system. However, there is a danger that parastatals could crowd-out private sector involvement and resume their previous role of a monopsonist.

Futures contracts can play a significant role under the current cotton commercialization system in FPA countries and also during the transitional period to a more liberalized system. Given the limited coverage provided by forward sales, there is scope for cotton futures contracts in complementing forward sales in hedging price risk. The use of futures contracts can smooth intra-year price volatility and can provide a mechanism for adjustment to medium and longer term price movements. In addition, use of future contracts can make withdrawals from or accruals into the existing cotton stabilization funds more predictable. To the extent that cotton prices follow a random walk pattern, at least in the short to medium run (as do other commodity prices), the stochastic component of price variability can become overwhelming, thereby increasing the error associated with price expectations and hampering the ability of stabilization fund managers to determine a "long-run" support price.[8] In addition, the use of financial instruments will generate revenue-based risk benefits for governmental backing of stabilization funds.

The use of futures/options can also provide valuable flexibility to marketing agents in FPA cotton producing countries. Forward sales assume that exporters have to find a buyer which at times may be difficult. Futures markets are always there and have enough liquidity for relatively small cotton producers such as the FPA countries.[9] Thus, using futures contracts can be of help in cases of inadequate liquidity in the physical market (no immediate buyers).

To a certain extent, the use of futures contracts, forward sales and stabilization funds, substitute for and complement each other. However, futures and forward sales remove mainly intra-year price volatility while stabilization funds are more useful for the reduction of inter-year price volatility. Given the importance of futures contracts in risk sharing and reducing short-term price volatility under both the current and a liberalized marketing system, we proceed with the quantification of the risk reduction benefits from hedging FPA cotton prices.

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[8]Larson and Coleman (1991) showed that the use of market-based financial instruments, such as futures and options, can increase the probable life of stabilization funds.

[9]As stated earlier, a volume equivalent to 2/3 of FPA annual cotton production is traded everyday in the New York cotton exchange.

In the remainder of the paper, simulations are performed to quantify the reduction in cotton price volatility from using the New York No. 2 cotton futures contract.

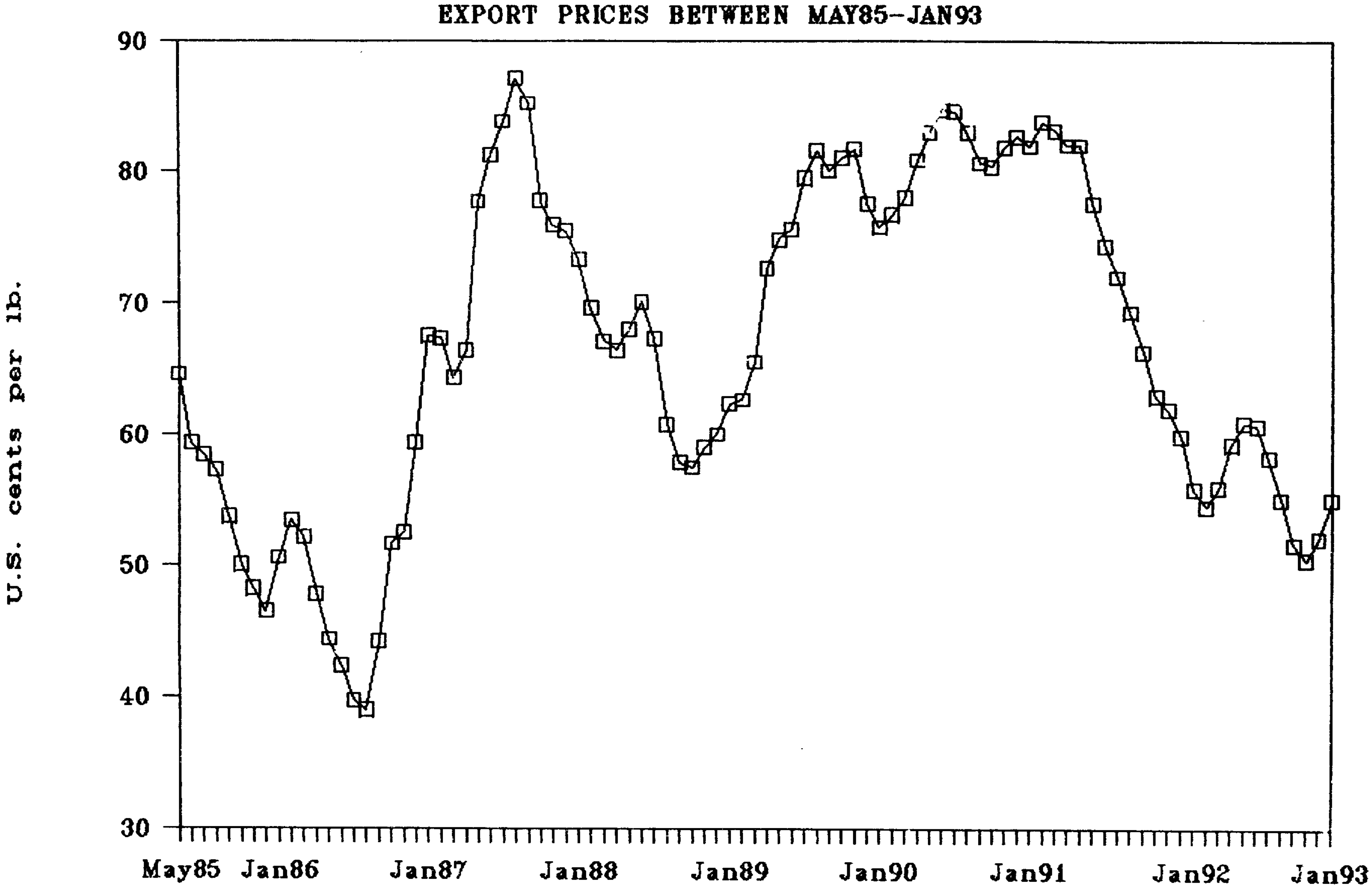
II. HEDGING THROUGH NEW YORK COTTON FUTURES

Prices received for FPA cotton have fluctuated significantly, especially in the latter half of the 1980's. Figure 1 depicts the volatility of FPA cotton export prices (c.i.f. North Europe) over the period May '85-Jan '93. The average monthly export price over this period was US¢66.64/lb with a standard deviation of ¢12.78. In the sub-period Jan. '86 and Dec. '90, price volatility was somewhat higher, with a standard deviation of ¢13.16 around a mean price of ¢68.87/lb. Thus the coefficient of variation for the period Jan. '86-Dec. '90 is 19.1% which is higher than the volatility of world prices over the same period. This volatility is estimated to be around 17%.

Futures markets provide a convenient mechanism for hedging this type of risk.[10] However, the only market that trades in cotton futures is the New York Cotton Exchange (NYCE). The New York No. 2 cotton contract is based on grade 41, staple 34 (strict low middling 1-1/16 inch) cotton. The quality of FPA cotton is similar (middling 1-3/32 inch) but not identical. Provided that the characteristics of the cash commodity is identical to the quality specified in the futures contract, the traditional recommendation is to hedge all of the cash commodity in the futures market. (This

[10]Since options are options on futures contracts, the analysis presented here can be easily extended to include options strategies. In addition, the analysis to determine the basis risk is applicable to the use of options on these futures contracts.

FIGURE 1


EXPORT PRICES BETWEEN MAY85-JAN93
U.S. cents per lb.
90
80
70
60
50
40
30
May85
Jan86
Jan87
Jan88
Jan89
Jan90
Jan91
Jan92
Jan93

type of a hedge is termed a "direct hedge"). However, in cases where the cash and futures prices are for related but not similar commodities, the appropriateness of the futures contract for "cross-hedging" needs to be determined.[11] A simple method of determination is to see how closely the cotton futures price and FPA cotton export prices move together. In general, the higher the correlation the greater the effectiveness of a hedge. Table 4 shows the results of an OLS (Ordinary Least Squares) regression in which (nearby) futures price changes were regressed on FPA cash price changes.[12] The R-square measure indicates that 30% of the variance of cash price changes is explained by futures price changes. The percentage of the variation in cash price changes which is unexplained (1-R square = 70%) is an estimate of the basis risk. Thus, the basis risk is high but this is to be expected because the underlying cash and futures prices are for different grades of cotton and US policy has to some extent insulated US markets from the world cotton market. A cross-hedge in this situation is still feasible but the optimal quantity to be hedged as a percentage of the cash commodity - i.e., the optimal hedge ratio - needs to be

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[11]A typical cross-hedge in cotton is to hedge the price of one quality by using a futures contract based on a marginally different quality, such as West African Cotlook A index cotton (middling 1-3/32 inch quality) being hedged with a New York number 2 futures contact based on strict low middling 1-1/16 inch quality. The futures contract would be liquidated simultaneously with the sale of the physical cotton.

[12] Note that the OLS regression uses price changes rather than price levels because cash and futures prices of most commodities are non-stationary (Milonas and Vora, 1987). A simple transformation such as using differenced data, as we have done, controls for price-level non-stationarity.

Table 4: Regression Results for Test of Basis Risk

Regression	α	β	R^2	D-W
$(S_{t+1} - S_t) = \alpha + \beta (F_{t+1} - F_t)$	-.09	.34*	.30	1.30
	(-.32)	(6.14)		
$(S_{t+1} - S_t) = \alpha + \beta (I_{t+1} - I_t)$	-.04	.80*	.80	2.08
	(-.25)	(19.04)		

Notes: 1. Monthly data for the period May '85 - Jan. '93 (93 observations) were used in both regressions. S stands for the spot price, F for the futures price and I stands for the price of the Cotlook A Index and D-W for the Durbin-Watson Statistic. T-statistics are in parenthesis and starred variables indicate significance at the 99% level.

2. The Cotlook A Index is published daily by Cotlook Limited, a cotton information service in the United Kingdom. The A index is an average of the 5 lower quotes in US¢/lb for cotton being offered in significant quantities from 14 cotton growing regions in 13 producing countries. The Index is based on cotton comparable to middling 1-3/32 inch quality by the "Liverpool" concept, delivered C.I.F. North Europe, cash against documents on arrival of vessel, including profit and agent's commission. The Index is presented as an indication of the competitive level of offering prices.

3. All variables are stationary in first differences.

empirically determined. The optimal hedge ratio depends upon the hedger's level of risk-aversion. Hedging is useful if the reduction in risk is sufficient to compensate for the reduction in returns. We report calculations of the optimal hedge ratios for FPA cotton at different levels of risk aversion later in the paper.

Before a determination of the optimal hedge ratio is made it would be of interest to check the relationship between FPA cash prices and Cotlook A Index prices. This is because a recently introduced cotton futures contract based on the Cotlook A index may make this contract a more appropriate hedging instrument than the New York No. 2 futures contract.[13] Table 4 reports the results of regressing Cotlook A Index price changes on FPA cotton price changes.[14] The R-Square indicates that 80% of the variation in FPA cotton prices is explained by changes in the Cotlook A Index. This reasonably good fit is not surprising given that FPA cotton prices form one of the thirteen components of the Cotlook A index. The fact that FPA prices and Cotlook prices were significantly correlated[15] implies that the Cotlook futures contract may prove a better hedging instrument for FPA cotton than the New York No.2

[13]For the definition of the Cotlook A index see note #2 under Table 4.

[14]We use spot-to-spot regression rather than spot-to-futures because there is not sufficient data on Cotlook futures prices. We, therefore, assume a close relationship between Cotlook index prices and Cotlook futures prices.

[15]The correlation between SSA export price changes and Cotlook price changes is 0.89. The correlation coefficient turned out to be significant at the 99% level.

cotton futures contract. However, the present very low level of liquidity of the contract is likely to discourage use of this contract for hedging purposes.

Although the New York number 2 cotton futures contract represents a cross-hedge, it was effective in decreasing volatility in the simulations. Moreover, the New York Cotton Exchange has added additional serial months to the Cotlook World Cotton Futures contract--for which settlement is based on the Cotlook A Index--to increase the trading and hedging opportunities for market users. In addition to the regular cycle months of March, May, August, October, and December, two spot or serial months from the January, February, April, September, and November cycle will also be available. The Exchange anticipates that the addition of rolling spot months will increase the contract's liquidity and afford hedgers and speculators a more viable trading vehicle.

II.1 Risk Minimization (Ex-Ante Risk-Minimizing Hedges)

We turn now to analyzing the risk management prospects for FPA cotton. We will assume throughout this section that the objective of the hedger is simply to minimize risk.

The FPA hedging decision can be thought of as a portfolio selection problem in which the hedger selects the optimal proportions of unhedged (spot) and hedged (futures) output.[16] The FPA portfolio can then be represented as:

$$ER_p = Q \ E(S_{t+1} - S_t) + Q_h \ E(F_{t+1} - F_t) \ \ldots\ldots\ldots\ldots\ldots (1)$$

where:

ER_p = Expected return on the hedged portfolio

Q_u = Unhedged output

$E(S_{t+1} - S_t)$ = Expected change in the FPA export price from time t to time t+1

Q_h = Hedged output

$E(F_{t+1} - F_t)$ = Expected change in the futures price from time t to time t+1

Note that $(Q_u + Q_h) = Q_e$, the amount of output available for export. At time period t, the values of S_{t+1} and F_{t+1} are unknown. These are, therefore, random variables. In a hedge, Q_u and Q_h have opposite signs. For instance, in a short hedge, a long position in the spot market ($Q_u > 0$) is offset by a short position in the futures market ($Q_h < 0$). Rewriting equation 1 for a long cash/short futures position we have:

$$ER_p = Q_u \ [\ E(S_{t+1} - S_t) - (Q_h / Q_u) \ E(F_{t+1} - F_t)] \ldots\ldots\ldots (2)$$

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[16] In terms of conventional portfolio theory, hedged output can be thought of as a riskless asset and unhedged output as a risky asset.

Let h = (Q_h / Q_u). If the value of Q_u is set equal to 1, then h can be interpreted as the hedge ratio - the percentage of the spot or cash position that is hedged in the futures market. Thus,

$$ER_p = E(S_{t+1} - S_t) - h\,E(F_{t+1} - F_t) \quad \ldots\ldots\ \ldots\ldots\ldots (3)$$

If the portfolio is completely hedged, that is, each unit in the spot market is hedged with a unit of futures, then h = 1. (This type of a hedge is called a "naive hedge".) If h = 0, then there is no hedging and the expected return on the portfolio is simply equal to the return on the spot market.

The variance of the portfolio is a measure of the risk of the portfolio. The variance of the portfolio (Var(P)) is given by:

$$Var(P) = Var(S) + h^2\,Var(F) - 2\,h\,cov(S,F) \ldots\ldots\ldots\ldots (4)$$

where:

Var(S), Var(F) = variance of spot and futures price changes

cov(S,F) = covariance between spot and futures price changes

Recall, that we assumed that the objective of the FPA countries was simply to minimize risk. The problem then is to identify a h, such that Var(P) is minimized. This can be done by differentiating Var(P) with respect to h as follows:

$$\partial\, Var(P) / \partial h = 2\, h\, Var(F) - 2\, cov(S,F) = 0$$

Solving for h from the above results in:

$$h^{*} = cov(S,F) \;/\; Var(F) \qquad (5)$$

It can be shown that h^{*}(the risk-minimizing hedge ratio) is simply the slope coefficient of an OLS linear regression of futures price changes on spot price changes (see Ederington, 1979).

We constructed three ex-ante hedges for FPA cotton using the risk-minimizing hedge ratios. The sowing season for FPA cotton ends around July-August (see Table 2) and cotton is sold forward continuously from then onwards until about June of the next year. Table 3 indicates that 85-95% of FPA cotton is sold by about May. No data on forward prices were available so we used futures prices to simulate hedges over a period of three years to evaluate the risk management prospects for FPA cotton through hedging in the futures market. We assumed that the hedge is placed in October of each year by buying the July No. 2 contract and lifted at the end of June before the contract matures. The timing of the hedge, therefore, approximately coincides with the cotton season in FPA countries. Hedges for 1989, 1990, and 1991 were constructed in this manner.[17]

The risk-minimizing hedge ratios for each year were calculated by using information available only up to the period in which the hedge was placed. Thus, the hedge ratio for the Oct. 1989 hedge was estimated using data between Sept. 1985 and Sept. 1989; the hedge ratio for the Oct. 1990 hedge was estimated using data between Sept. 1985 and Sept. 1990, and so on. These hedges are thus ex-ante hedges.

Table 5 reports the estimated risk-minimizing hedge ratios and contrasts the performance of three portfolios - Unhedged, Naive, and Risk-Minimizing - over the life of the hedges. It is apparent from the results that in every one of these hedges the risk of the unhedged position exceeded the risk of the hedged position. Notice also that if a policy of covering all of the spot position in the futures market had been followed, the risk of the naive portfolio would have been less than the unhedged portfolio in two of the hedges but substantially more than the unhedged in one of the hedges[18]. This is not surprising given that naive hedges work well only when the spot commodity and the futures commodity

[17]The estimated risk-minimizing hedge ratios appear to be very similar for each of these periods. This indicates the robustness of the estimated hedge ratio over periods (see Table 5).

[18]In the Oct. 1991 hedge the variance of the naive portfolio is less than the variance of the risk-minimizing portfolio. It should be remembered that the risk-minimizing portfolio is ex-ante risk-minimizing. The ex-post risk-minimizing portfolio may be quite different.

are identical.

We can also calculate the risk reduction benefits of hedging as the percentage of the unhedged variance that the risk-minimizing or naive hedge eliminates. Thus,

% Reduction in Risk = 1 - [Var(Hedged)/Var(UnHedged)]

These benefits range from 60.3% for the Oct. 1989 risk-minimizing hedge to -121.3% for the Naive hedge of Oct.1990. The negative sign implies that by hedging all output, the risk of the naive portfolio actually increases over that of the unhedged portfolio. This simply reiterates the fact that naive hedges are inappropriate for FPA cotton. Table 5 actually increases over that of the unhedged portfolio. This simply reiterates the fact that naive hedges are inappropriate for FPA cotton.

One other important point needs to be made about these hedges. In one of the years, the unhedged portfolio gave a higher (positive) return than the risk-minimizing portfolio. In the other two years, the risk-minimizing and unhedged positions both lost money, with the risk-minimizing position losing almost twice as much as the unhedged in one case. Hedging carries a cost in terms of foregone returns and whether the hedger considers these costs reasonable or not depends upon attitude to risk (i.e. degree of

Table 5: Performance of Hedged and Unhedged portfolios.

Portfolio	Hedge Ratios	Return	Variance	Risk Reduction
October 1989 Hedge				
Unhedged	h = 0	.47	5.29	-
Naive	h = 1	-.32	2.96	44.0%
Risk-Minimizing	h* = .298	.23	2.10	60.3%
October 1990 Hedge				
Portfolio	Hedge Ratios	Return	Variance	Risk Reduction
Unhedged	h = 0	-.34	3.80	-
Naive	h = 1	-1.36	8.41	-121.3%
Risk-Minimizing	h* = .309	-.66	1.54	59.5%
October 1991 Hedge				
Portfolio	Hedge Ratios	Return	Variance	Risk Reduction
Unhedged	h = 0	-.68	6.71	-
Naive	h = 1	-.07	4.45	33.7%
Risk-Minimizing	h* = .314	-.49	4.54	32.3%

Notes: A negative sign for risk-reduction indicates risk-increasing rather than risk-reducing.
L = 0 means completely unhedged.
L = 1 means fully hedged.
h* = is the optimal hedge ratio.

risk-aversion).[19] We have assumed in this section that FPA countries are risk-minimizers and we have been able to show that *ex-ante* hedging can reduce risk. All the three hedges we simulated were, from the standpoint of risk-minimization, successful.

II.2 Risk Aversion and Ex-Post Hedges

We have assumed up to this point that the objective of FPA countries is to minimize risk and we have shown in the previous section that risk reduction through hedging is certainly possible. However, risk reduction generally carries a cost in terms of foregone returns as we pointed out earlier. Whether the hedger minimizes risk or maximizes return depends upon the level of risk aversion. If the hedger is infinitely risk-averse minimizing risk is the appropriate choice, whereas a hedger with a low level of risk aversion would be willing to bear a substantial amount of risk for the opportunity of increased returns. In this section, we quantify the risk-return trade-offs from hedging FPA cotton and estimate the optimal hedge ratios at different levels of risk aversion.

In order to introduce risk aversion into the analysis, we need to modify the portfolio model of hedging developed earlier. Suppose now that the expected utility (EU) function of FPA

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[19]Additional costs include the brokerage fee (usually 1 thousandth of the contract value) and the opportunity cost of holding a margin account--i.e., the difference between the interest bearing notes of the margin account and investing somewhere else. However, these costs are considered very small.

countries is a function of the expected return (ER_p) and variance of the portfolio Var(P). Thus,

$$EU = E(R_p) - \lambda \, Var(P) \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where λ is a risk aversion parameter and $E(R_p)$ and Var(P) are as defined in equations 3 and 4 respectively. Higher (lower) values of λ imply higher (lower) levels of risk aversion. The model above is a mean-variance model (see Markowitz, 1959) and implicitly assumes that the hedger has a quadratic utility function or that returns are normally distributed.[20] The optimization problem is to select the h which will maximize EU. Thus,

$$\partial EU/\partial h = - E(F_{t+1}-F_t) - 2\lambda h \, Var(F) + 2\lambda \, cov(S,F) = 0$$

Solving for the optimal (utility-maximizing) hedge ratio, h^{**}, from the above gives,

$$h^{**} = [cov(S,F) / Var(F)] - [E(F_{t+1}-F_t) / 2\lambda \, Var(F)] \ldots\ldots (7)$$

Using equation (5) this may be rewritten as:

[20] Quadratic utility functions raise several theoretical problems (see Arrow, 1971) but work by Levy and Markowitz (1979) and Kroll, Levy, and Markowitz (1984) suggest that the assumption of quadratic utility is a reasonable empirical approximation.

$$h^{**} = h^{*} - [E(F_{t+1}-F_t) / 2\lambda \, Var(F)] \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

The first term in equation (8) is called the hedging component and this is, of course, the same as the risk-minimizing hedge ratio. Notice that if $\lambda \rightarrow \infty$ (i.e., infinite risk-aversion) the second term disappears and the optimal (utility-maximizing) hedge ratio is, in this case, the same as the risk-minimizing hedge ratio (i.e. $h^{**} = h^{*}$). The second term in equation (8) is called the speculat e component and this is inversely related to λ and positively related to the "bias" between the current and the expected futures price. The speculative component essentially captures the effect of hedging on expected returns.

We estimated ex-post optimal hedge ratios for FPA cotton using the July 1990 futures contract. We assumed that the hedge was placed in the first month of trading of the July contract in March 1989 and lifted in June 1990 before the expiration of the contract. Table 6 reports estimates of the optimal hedge ratio at different levels of risk aversion and the associated return and risk levels. It is clear from the table that for values of λ between 10 and infinity, the optimal hedge ratio is essentially constant, implying that for these values of risk aversion, the speculative component is insignificant. This result is similar to Rolfo's (1980) result on optimal hedging for cocoa producing countries and Ouattara, Schroeder, and Sorenson's (1992) work on coffee hedging for Côte d'Ivoire. At values of λ equal to or lesser than .10, the results

Table 6: Optimal Hedge Ratios, Return and Risk at Varying Levels of Risk Aversion

Risk Aversion Parameter λ	Optimal Hedge Ratios h^{**}	Return	Variance
∞	.6547	0.53	3.39
10,000	.65	0.53	3.39
1,000	.65	0.53	3.39
100	.65	0.53	3.39
10	.65	0.53	3.39
1.0	.58	0.61	3.44
.10	-.12	1.41	7.83
.01	-7.05	9.40	447.02
.001	-76.36	89.25	44,365.60
.0001	-769.53	887.78	4,436,223.14

imply that FPA countries should buy rather than sell futures (i.e. negative values of h^{**} imply a long position in futures). This is not a surprising result in view of the relation that existed between F_t and $E(F_{t+1})$ over the period of the hedge between March 1989 and June 1990. Equation (8) implies that the mean bias between the futures price at time t+1 and t, is negatively related to h^{**}, *ceteris paribus*[21]. Over the hedge period, the mean value of $(F_{t+1}-F_t)$ was equal to 1.152. Given that the mean *ex-post* bias was positive, it is not surprising that at lower levels of risk aversion the recommendation is to go net long in futures to profit from this bias.

We calculated portfolio returns and variances for hedge ratios between 0 and 1. These results are reported in Table 7 and graphed in Figure 2. Figure 2 is a "mean-variance opportunity set" and depicts the risk-return trade-offs from hedging FPA cotton. Point M is the minimum variance portfolio with a return of 0.53 and a variance of 3.39. Portfolios on the negatively sloped portion of the opportunity set are inefficient because, for the same variance, portfolios on the positively sloped portion yield a higher return. This means that we can effectively eliminate all portfolios with hedge ratios greater than the minimum variance hedge ratio since

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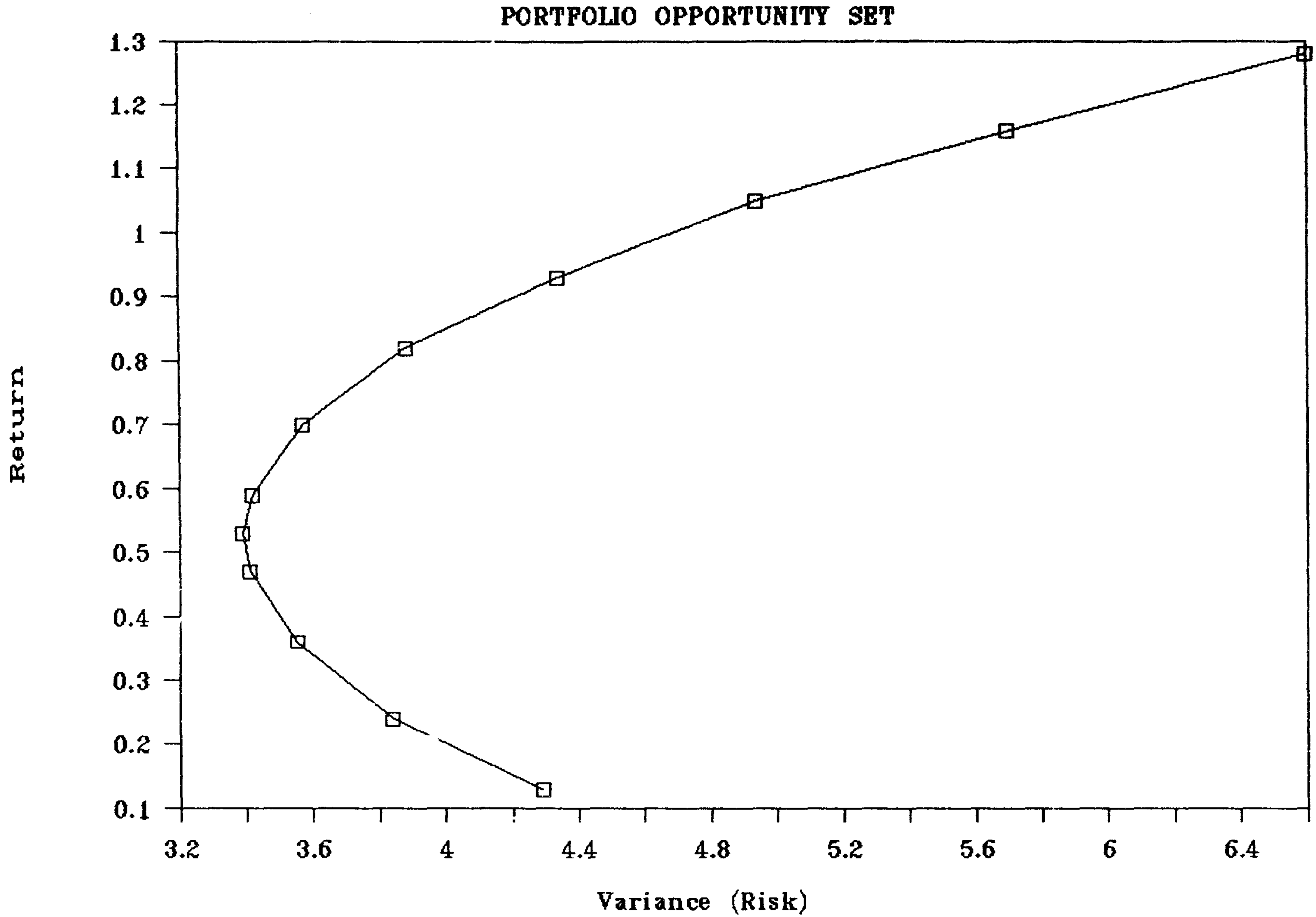
[21]Equation 8 also implies that if the current futures price is an unbiased estimate of next period's futures price (i.e. $F_t = E[F_{t+1}]$) the speculative component in h^{**} disappears and $h^{**} = h^*$. Thus, in an unbiased futures market, the risk-minimizing hedge ratio is equal to the optimal hedge ratio.

Table 7: Risk-Return Trade-Offs

Risk-Aversion Parameter λ	Optimal Hedge Ratio	Return	Variance	% Reduction in Return	% Reduction in Variance	Cost
.1176	0	1.28	6.60	-	-	-
.1388	.10	1.16	5.70	9	14	.66
.1694	.20	1.05	4.94	18	25	.72
.2171	.30	.93	4.34	27	34	.79
.3024	.40	.82	3.88	36	41	.87
.4978	.50	.70	3.57	45	46	.98
1.4078	.60	.59	3.42	54	48	1.12
∞*	.6547*	.53*	3.39*	59*	49*	1.21*
-1.70	.70	.47	3.41	63	48	1.30
-.53	.80	.36	3.55	72	46	1.56
-.31	.90	.24	3.84	81	42	1.94
-.22	1.0	.13	4.29	90	35	2.57

Note: *Indicates values associated with the minimum-variance portfolio.

FIGURE 2


PORTFOLIO OPPORTUNITY SET
Return
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
3.2
3.6
4
4.4
4.8
5.2
5.6
6
6.4
Variance (Risk)

these lie on the negatively sloped portion of the opportunity set.

In Table 7, hedge ratios greater than the minimum-variance hedge ratio are associated with negative values of λ. This implies that portfolios associated with these hedge ratios will never be selected unless the utility function is negatively sloped in mean-variance space. A negatively sloped utility function implies a risk-lover rather than a risk-averter. The negative values of λ simply confirm that with risk-aversion, portfolios on the negatively sloped portion of the opportunity set cannot be optimal.

We also calculated the explicit costs of hedging FPA cotton. We compared the return and risk of the unhedged position with the return and risk of the hedged positions to calculate a cost elasticity measure as follows:

Cost of Hedging = (%Reduction in Return) / (% Reduction in Risk)

where:

% Reduction in Return= 1 - [(Return of Hedged) / (Return of Unhedged)]

and the percentage reduction in risk is as defined earlier. These costs are shown in the last column of Table 6 and range from a low of .66 to a high of 2.57 with larger values implying higher costs of risk reduction. The cost associated with the minimum-variance portfolio is 1.21 which implies that a 1% reduction in risk will result in a 1.21% reduction in return. Whether this is a reasonable cost of hedging or not depends upon the FPA countries risk aversion. The particular point on the efficient frontier where the FPA countries will choose to lie depends upon their subjective risk-return attitudes.

II.3 Sensitivity of the Optimal Hedge Ratio to Changes In the Bias

We mentioned in the previous section that over the sample period, the ex-post bias (b) between current and expected futures prices (i.e. $b = [F_{t+1} - F_t]$) was positive leading to the recommendation to go net long in futures at low levels of risk aversion. The bias, however, tends to fluctuate from one period to another and there is no a priori reason why it could not be either positive or negative. Hence, it is important to investigate the effect of changes in the bias on the optimal hedge ratio.

A straightforward way of determining the effect of the bias on the optimal hedge ratio is to differentiate equation 8 with respect to b, holding everything else constant. Thus,

$$\partial h^{**}/\partial b = - [1 / 2\lambda \, Var(F)] < 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

The result of this differentiation indicates that for <u>given (positive, finite) values of λ</u>, a marginal increase in b will lead to a decrease in the optimal hedge ratio. Table 8 reports the marginal effects of increases in b on the optimal hedge ratio for given levels of risk aversion. Notice that at larger values of λ the marginal effect of an increase in b is virtually insignificant. Figure 3 depicts the effects on the optimal hedge ratio of changes in the bias for two low values of risk aversion; λ=1.4078 and λ=.1176[22]. Notice that even at the fairly low λ value of 1.4078, the optimal hedge ratio barely declines even though the bias changes considerably. At λ = .1176, however, the response to a change in the bias is considerably stronger. (The slope of the curve, $\partial h^{**}/\partial b$, at λ=1.4078 is -0.569 and the slope at λ=.1176 is -0.047, see Table 8.) These results indicate that except at very low levels of risk aversion, changes in the bias do not significantly affect the optimal hedge ratio.

Even though changes in the bias do not significantly affect the optimal hedge ratio at larger values of risk aversion, they change considerably the shape (and risk-return trade-offs) of the portfolio opportunity set. Figure 4 graphs two portfolio opportunity sets. The first of these is a reproduction of Figure 2 which is drawn using the ex-post bias value of 1.152. The second portfolio set is drawn on the assumption of a lower bias value of

[22]There is nothing distinctive about these risk aversion values except that they correspond to optimal hedge ratio values of 0 and 0.60 in Table 6.

Table 8: Marginal Effects of an Increase in the Bias at Varying Levels of Risk Aversion

λ	$\frac{\delta h^{**}}{\delta b}$
∞	0
10,000	-.000
1,000	-.000
100	-.001
10	-.007
1.4078	-.047
1.0	-.067
.4978	-.134
.3024	-.221
.2171	-.308
.1694	-.395
.1388	.482
.1176	-.569

FIGURE 3 – EFFECT ON THE OPTIMAL HEDGE

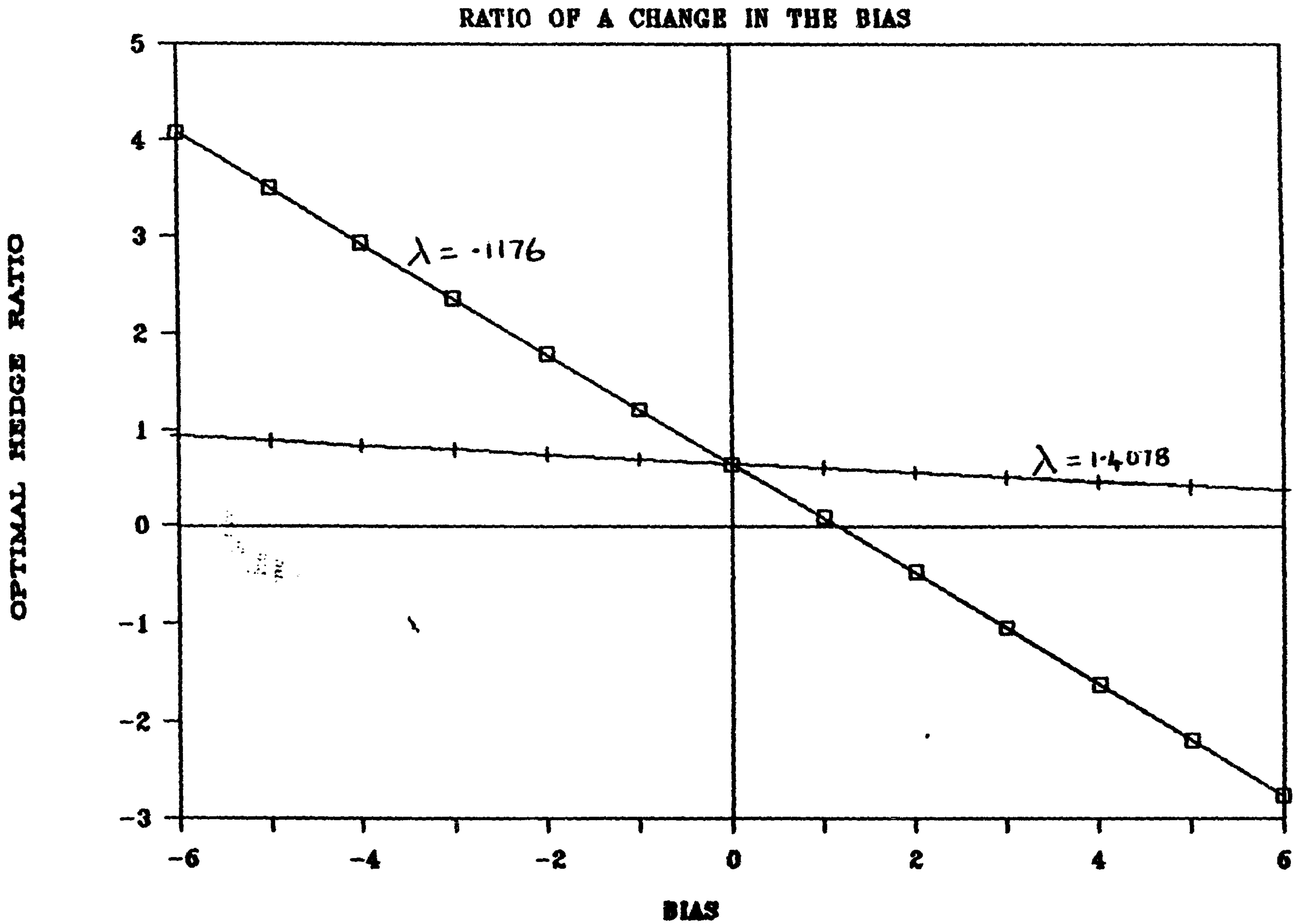
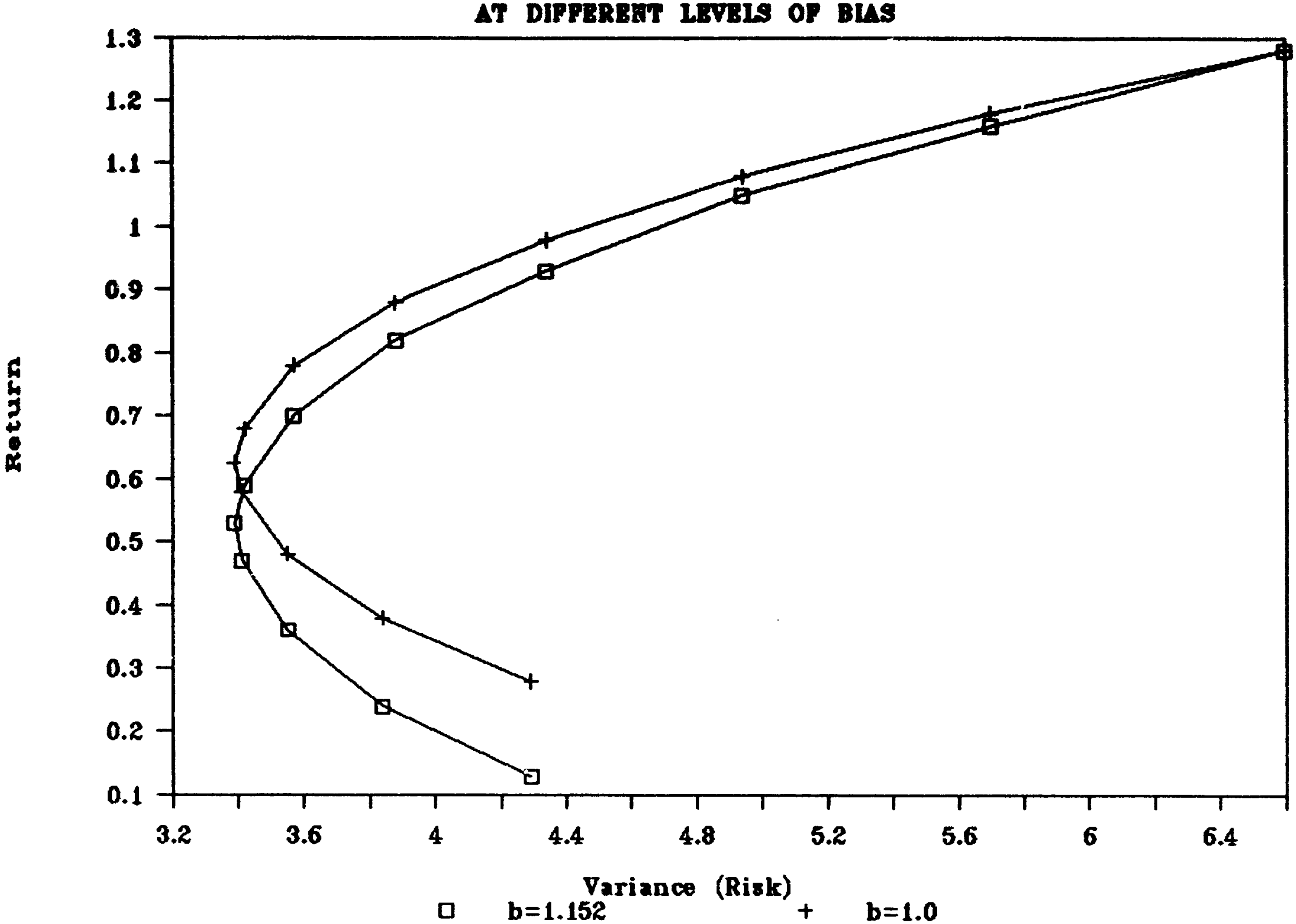


FIGURE 4 – PORTFOLIO OPPORTUNITY SET



1.0,[23] with everything else remaining constant. Notice that the portfolio set corresponding to b=1 lies above the original portfolio set. The intuition behind this result is that a lower bias, ceteris paribus, implies better returns from short-hedging. Assuming that the underlying variance has not changed, return is higher for the same level of risk, thus lowering the opportunity costs of hedging. On the other hand, increases in the bias, ceteris paribus, will shift down the portfolio set, leading to a lower return for the same risk and increasing the opportunity cost of hedging.[24]

We emphasize again that a positive bias is just as probable as a negative bias. The risk-return trade-offs in the sample period depended upon a particular spot-futures price relationship. These trade-offs would, of course, be different in another period. In the long run, however, the expected gains from hedging will tend to zero. For a risk-averse hedger, the benefits of hedging lie not so much in any potential for increased returns as in the reduction in variance.

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[23]This value was chosen purely for illustrative purposes. Any value different from the original bias value of 1.152 would have served our purpose just as well.

[24]Ederington (1979) defines the basis as: $(F_{t+1}-S_{t+1}) - (F_t-S_t)$. This can be rewritten as: $(F_{t+1}-F_t)-(S_{t+1}-S_t)$. Holding $(S_{t+1}-S_t)$ constant, an increase in the futures bias increases the basis and a decrease in the futures bias decreases the basis. A decreasing bias, and consequently a decreasing basis, increases the returns to short-hedging (see Working, 1953). Thus, the discussion here could also have been conducted in terms of changes in the basis.

III. SUMMARY AND CONCLUSIONS

Cotton exports are a significant part of agricultural and total export revenues for the majority of Francophone African countries. In most cases the share of cotton exports has increased, which means that Francophone African countries have increased exposure to cotton price volatility.

The major part of the cotton price risk has been borne by the parastatal marketing authorities and ultimately by the government. This was because of the fixed prices paid to producers. This fixity created problems during periods of persistent cotton price declines. Recent reforms have lessened some of the governments' exposure to cotton price volatility by introducing flexibility into the producer pricing system. This was done by linking the final producer return to actual export revenues. At delivery, cotton producers now receive about 80% of the floor price announced at the beginning of the planting season with the balance paid at the end of the season. However, the adoption of such a measure still leaves a large part of the cotton price risk with the government. (Additional noteworthy reforms include increases in the operational efficiency of the parastatals, reductions in cotton marketing costs, and changes in taxation).

Francophone countries have depended heavily on the use of stabilization funds to provide price stabilization. In theory, funds are accumulated during periods of high prices and are paid out during periods of low prices. However, in practice, the available funds were often insufficient during periods of low prices, creating budgetary problems for governments.

In recent years, the main risk management instrument used by Francophone African cotton producers has been the forward contract. Countries usually sell forward about one-fourth to one-third of their expected crop before they announce producer prices. That still results in significant government exposure as the major part of the crop is unhedged before producer prices are set.

The idea behind forward sales is that they provide a hedge for the stabilization fund. By obtaining a price for future exports, forward sales increase the predictability of accruals or payments from the stabilization funds. In a sense, therefore the fund can be though of as a means to stabilize inter-year price movements while the forward sales stabilize intra-year price movements. This does not make the fund immortal, but does increase the likelihood of survival. However, use of forward sales has limitations as they rely on a buyer being available at the appropriate time. Futures contracts do not have this constraint--as liquidity is usually firm up to 12 months ahead. Thus futures contracts could be used in addition to the forward sales to cover the remaining price risk.

As economic reforms progress in the FPA countries, the need for effective commodity price risk management will increase. Primary goals will be to remove the impediments to transparent price formation, so that prices at each marketing stage will reflect an appropriate relationship to final demand for the product and to provide incentives for market participants to hedge price risks. Information to achieve these goals includes: well defined product quality standards, marketing and processing agents and transportation and storage systems operating competitively, and freedom for all participants to sell products in domestic or export markets. Under these conditions the domestic marketing system will be efficient as will be the allocation of production resources. If the exporters are to undertake the risk management, which ultimately will benefit the farmers, prices will need to be transmitted in a transparent and efficient manner. The creation of domestic spot markets for cotton may be a first step towards this end. A forward market could be developed at some later stage. Domestic spot and forward markets provide opportunities for price discovery, crop financing and risk sharing.

To see the benefits which could be gained from use of futures contracts, this paper investigated the risk reduction prospects for FPA cotton using portfolio analysis. A portfolio model of hedging was developed in which the decision problem was to select the optimal hedge ratio under two behavioral assumptions - risk minimization or utility maximization under risk aversion. We found that "cross-hedges" for FPA cotton have significant risk reduction potential. We simulated ex-ante cross-hedges for three years (1989, 1990, 1991) and found that in each case, hedging was effective in reducing price risk.

We also investigated the effect of risk aversion on the optimal hedge ratio under the assumption of a quadratic utility function. We found that over a large range of risk-aversion values, the risk-minimizing hedge ratio was virtually constant. For most practical purposes it seems that the assumption of risk-minimization is eminently reasonable. We found that for most plausible values of risk aversion, the recommended hedge ratio was significantly less than one, with estimates of the optimal hedge ratio (both ex-ante and ex-post) ranging between 0.29 to 0.65.[25] At very low values of risk aversion our results indicate that long hedging would be optimal.

We also quantified the opportunity costs of hedging in terms of foregone returns. Our results indicate that over the sample period, 1% reduction in risk could lead to a reduction in return between 0.66% and 1.12%. We also discussed the manner in which changes in the bias affect the optimal hedge ratio and the portfolio opportunity set.

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[25]The hedge ratio indicates the amount of futures contracts needed to hedge a certain quantity of the physical commodity. For example, for cotton, a hedge ratio of .5 indicates that for hedging 100,000 lbs of cotton one needs one N.Y. cotton futures contract (100,000 x .5 = 50,000).

We conclude that there are risk-reduction benefits from hedging FPA cotton using the New York No. 2 cotton futures contracts. We have also provided some estimates of the hedging cost that may aid in deciding whether the benefit-cost ratio of hedging is reasonable or not.

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